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(54) **SOURCE WAVEFORMS FOR
ELECTROSEISMIC EXPLORATION**

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G01V 1/40

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(58) Field of Search **367/38, 40, 191;**
324/323, 334, 354; 181/102, 106, 108

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,841,280 A * 11/1998 Yu et al. 324/323
5,877,995 A * 3/1999 Thompson et al. 324/323

OTHER PUBLICATIONS

Digital Communications with Space Applications, pp. 1-20,
165-167, Solomon W. Golomb, editor, Prentice-Hall Inc.
(1964). (No Month Given).

Zierler, Neal. "Linear Recurring Sequences", *J. Soc. Indust.
Appl. Math.*, vol. 7 (1), pp. 31-48 (1959). (No Month
Given).

Cunningham, Allen B., "Some Alternate Vibrator Signals,"
Geophysics vol. 44 (12), pp. 1901-1921, (1979). (No Month
Given).

Duncan, P.M. et al. "The Development and Applications of
a Wide Band Electromagnetic Sounding System Using a
Pseudo-Noise Source," *Geophysics* vol. 45 (8), pp.
1276-1296, (Aug. 1980).

Foster, M.R. et al. "The Use of Pseudonoise Sequences to
Code a Pulsed Neutron Logging Source," *Geophysics* vol.
37 (3), pp. 481-487, (Jun. 1972).

Kounias, S., et al. "On Golay Sequences," *Discrete Math-*
ematics 92, pp. 177-185, (1991). (No Month Given).

Yilmaz, O. "Seismic Data Processing," *Society of Explora-*
tion Geophysicists, pp. 18-19, (1987). (No Month Given).

Golay, M.J.E., "Complementary Series", *IRE Transactions*
on Information Theory, 7, pp. 82-87, (1961). (No Month
Given).

* cited by examiner

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(57) **ABSTRACT**

A method for seismic exploration using conversions
between electromagnetic and seismic energy, with particular
attention to the electromagnetic source waveform used.
According to the invention, source waveforms are correlated
with reference waveforms selected to minimize correlation
side lobes. Line power at 60 Hz may be used to provide a
waveform element which may be sequenced by a binary
code to generate an extended source waveform segment with
minimal correlation side lobes. Preferred binary codes
include Golay complementary pairs and maximal length
shift-register sequences.

20 Claims, 5 Drawing Sheets

